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ABSTRACT

This paper provides an introduction to the Alberta Education Developmental Framework, and describes the provincial department's position on curriculum and the cognitive domain. Intended for use in designing and implementing instruction, the developmental framework delineates the developmental stages and processes through which students progress, and includes material concerning the kinds of support students need in order to learn more effectively at various stages of growth. Appendices provide outlines of cognitive growth in general, and of affective and physical growth in early adolescence and middle adolescence. (RH)

Students' Thinking
Developmental Framework
Cognitive Domain

Alberta
EDUCATION
March, 1987

STUDENTS' THINKING

DEVELOPMENTAL FRAMEWORK: COGNITIVE DOMAIN

Alberta Education
March, 1987

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FOREWORD

> "The aim of education is to develop the knowledge, the skills and the positive attitudes of individuals so that they will be self-confident, capable and committed to seeking goals, making informed choices and acting in ways that will improve their own lives and the life of their community." (Secondary Education in Alberta, June 1985, p. 7)

How children and youths think, feel and grow affects how they learn best. During the past few years, knowledge about students' learning has increased significantly. This knowledge is very important to the development of curricula and teaching methods aimed at helping students realize their potential. The challenge is to use these new insights well.

For some time, Alberta Education has been incorporating what is known about students' intellectual, social/emotional and physical growth into the curriculum. A renewed effort to do this began with the contributions made by Marcia Johnston during her internship with the department. Through the ideas, examples, and research contributed by many people, and through the careful consideration given by professionals and parents, the work has evolved into the Alberta Education Developmental Framework.

The following paper presents an introduction to the Developmental Framework, describing the department's position on curriculum and the cognitive domain. This represents a significant initiative on the part of Alberta Education: to ensure that school curricula are developed to meet and extend student development through the cognitive stages. The department intends to incorporate this work into curricula as they are developed; teachers can ensure that this is carried through in the classroom.

It is intended that the department will publish further papers covering other elements of the Developmental Framework, specifically concerning student social/emotional and physical development and the interactions among the three domains. The Developmental Framework delineates the developmental stages and processes through which students progress. It includes the kinds of support students need in order to learn more effectively at different stages of growth. It will be used to help organize curriculum content so that it anticipates and is more in keeping with the changing needs and abilities of students.

INTRODUCTION

How children think, feel and grow affects how they learn best. Knowledge of the stages and processes that children go through can help us to design better curricula. The policy statement entitled, Secondary Education in Alberta, 1985 deals with this specifically in its second guiding principle for education:

The development and implementation of the instructional program must take into account the following considerations:

* the nature and needs of the learner
* the nature and needs of a changing society
* the nature of knowledge in each subject area
* the learning environment.

Many of the elementary curriculum guides also take explicit account of the nature and needs of the learner. For example, p. 11 of the Language Arts Curriculum Guide, 1982 gives a brief description of Piaget's stages of cognitive development.

Similarly, the forthcoming policy on articulation between Early Childhood Services and elementary education carefully considers how children learn best in the early years.

Early Childhood Services suggests that all instructional programs should be based on principles of child development. They explicitly mention seven principles which characterize the learning of young children:

1. Human development is a continuous, sequential, interactive process.
2. Early childhood is a particularly significant period in human development.
3. The self-concept is important in human development.
4. Children learn through interaction with their environment.
5. Play is essential to the child's development.
6. Parents are primary agents in the child's development.
7. There is need for coordinated, responsive services.

What stages and processes do our students go through during the school years? We can consider these under three headings:

1. How do teachers help students learn?
2. What are the normal stages of development?
3. What do we know about the learning process?

Note to the reader: The following treatment deals in multidiscipline examples. Be prepared for "jumps" among subject areas.

THE ROLE OF CONTEXT

Teachers teach. This is obvious, but let us examine one way of looking at what teaching is. Teaching can be thought of as managing interactions among the child, the content and the teacher. How does the teacher help the student to learn concepts and processes? This is done through providing contextual support.

For young children, from infancy to the early school grades, it is particularly easy to see that interaction with the environment is necessary for learning. In fact, students throughout the school years must interact with things and people as well as ideas in order to learn best. The importance of this interactive context for learning is often underestimated by teachers because they are so good at, and so used to, supplying contextual support. The pictures in early readers provide contextual support to a child learning to read. For older students, the text itself is contextual support for the complex ideas being taught. For both older and younger students, the teacher's questions and explanations provide support. They direct the student's attention to the relevant part of the task, thus focussing the student's attention. The background experience and language which the children bring with them also form part of the contextual support.

A teacher who compares a water molecule (H_2O) to a bologna sandwich (1 bologna = 1 oxygen, 2 slices bread = 2 hydrogen atoms) is providing context to help students learn quantities and ratios. The students' experience with sandwiches allows them now to visualize, or have an internal conceptual model, of that molecule. Later, in balancing equations, the students can "see" the process and therefore can estimate their answers. Suppose the teacher then asks the students for a model for salt (NaCl). A student might suggest an open face sandwich. That teacher is really teaching students that they can call up their own context. They can develop their own internal models. They can teach themselves. Isn't this our goal for students – that they become independent learners?

For young children, the context must be more immediate, more personal and more concrete than for older students. Base ten blocks are a good example of a conceptual model of the number system and are used to help young children understand something inherently abstract. A cube one centimetre on a side represents one. Ten of these attached in a row represent ten. Ten rows attached to form a flat plane represent one hundred. Ten flats attached to form a cube ten centimetres on a side represent one thousand. Children can see the relative magnitudes of 1, 10, 100 and 1000 with these blocks. They learn to understand borrowing and carrying in addition and subtraction because the rows (for tens) do not break apart – they must be traded for (exactly) 10 one centimetre cubes. In this way, the children are manipulating concrete, tangible objects as if they were manipulating the abstract ideas. This allows them to build their concepts about our number system.

Many junior high students tend to enjoy novels about teenagers with problems. They feel themselves to have similar problems and so they can identify with the fictional characters. They enjoy these because the fictional context is similar to their own context. What the students bring with them to the experience of reading those novels allows them to understand and enjoy the stories.

NORMAL COGNITIVE DEVELOPMENT

In learning to think, children go through a series of stages. These stages flow continuously from one to the next. They are not quite distinct stages like caterpillars becoming pupae in cocoons and then adults. Infants from birth to about 2 years learn through all of their senses, through their movements and through their actions. In this period, children lay the foundations of learning in language, spatial reasoning, time concepts and reasoning about cause and effect.

Preoperational Thinking (Ages 2 to 7 or 8)

During these years, children's thinking is qualitatively different from that of older children and adults. Young children have a perceptual orientation; that is, they focus attention on one perceptual aspect of a thing. In looking at a row of objects, for example, young children will tend to notice or "centre" on the length of the row, and ignore the number of objects which make it up. If you then spread the same number of objects further apart, the child will say there are now more in the row, because the row is longer.

When children focus on one perceptual aspect of a display, they tend to consider the state – in the previous example, the length of the row. They tend to ignore changes between states – moving the objects further apart. To think about things, children depend on the concrete things they can see or touch or hear or smell or taste. At this age, too, children cannot reverse a mental action or operation. In other words, they cannot yet mentally return to their starting point. Thus, a child may know he has a brother John, but declare that John does not have any brothers.

This perceptual orientation goes along with the artistic orientation which children tend to be developing at this age. They may become very good artists. They view everything as full of life and feeling. Cars and rocks may be thought of as living things because they move. Children think inanimate objects have feelings since they are able to move. This explains the popularity of stories like the little train who thought he could. Children don't make the same distinctions as we do between living and non-living things.

Because children have not yet developed straightforward adult-like logic, they tend to make "absurd" connections. They often come up with sayings adults judge as cute or inventive. A four year old might suggest that the car should hurry because the moon following the car might catch them. This lateral or divergent thinking decreases when the child enters the concrete operations stage and learns the logic of that stage. This may be one area in which teachers must help to retain and augment the divergent and creative skills of the child.

In these years, children learn language. This is a very great thing because learning a language is one of the ways they learn to use symbols. Using symbols means that children use a word, an object or an action to represent (or re-present) something that is not there. Because the children are still tied to the concrete, the symbols they use bear a resemblance to the thing represented. A piece of cloth may be a pretend pillow, or a stick may stand for a soldier. Words can also be used to reconstruct something that has happened or to ask about something that might happen.

In learning language, children are concerned about meaning. They want to understand, and will learn correct grammatical forms (if they are used by those around them) as a by-product of this focus on meaning. Now and throughout their development, language will play a crucial role.

Children do not yet classify or understand how to use general classes for organizing thinking. Therefore, they will tend to move from particular to particular: "I haven't had my nap yet, so it isn't afternoon." (Piaget, quoted in Crain, p. 97). The child here doesn't yet understand that afternoons are a general category of time which contain smaller pieces of time called naps.

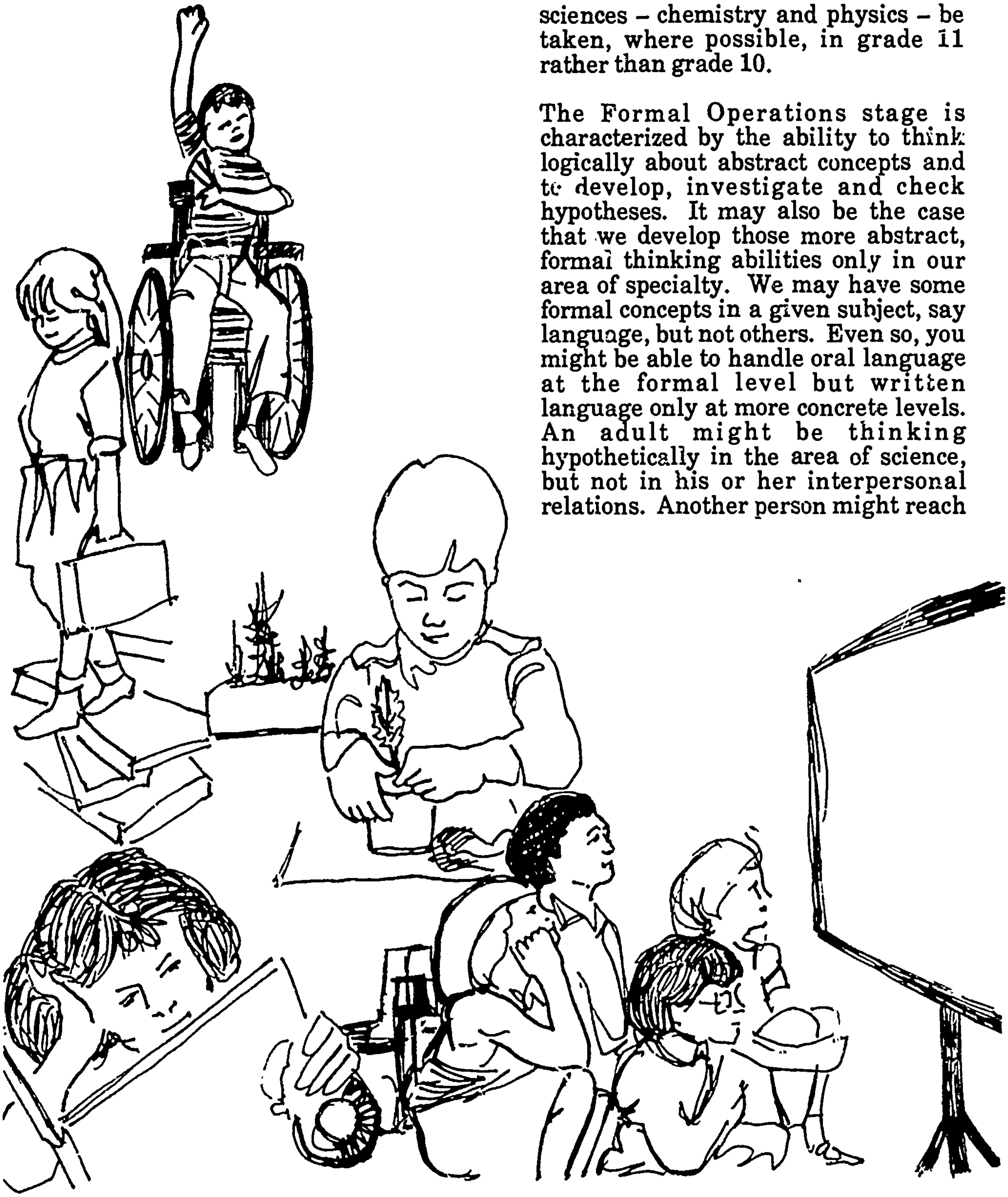
Finally, preoperational children are egocentric. This means that they normally consider things only from their own point of view. They expect that if they know something, then others must know it also. Providing children with familiar, concrete situations, where they can see other people's motives, can help them to overcome this egocentric perspective. In the main, however, young children tend to consider things from their own viewpoint only. A child may explain that her grandmother lives "over there", for example, expecting a stranger to know where "over there" is. Similarly, on a recent commercial, a child when asked his mother's name, responds "Mummy". That is, after all, his name for her.

Further Development of Thinking Skills

In the school years, from about grade 2 through to perhaps the end of grade 12, students think in concrete terms. The students' cognition is characterized by an ability to think logically about things and events in their immediate experience.

This information is relatively new. Piaget characterized this stage as Concrete Operations and viewed it as ending by 11 or 12 years of age. Many researchers have since established, however, that in this regard Piagetian age levels are more likely an optimum development schedule; students here as elsewhere, when they attain formal thinking, more often do so at about the grade 10 level. Perhaps this discovery explains why teachers so frequently recommend that the more abstract sciences – chemistry and physics – be taken, where possible, in grade 11 rather than grade 10.

The Formal Operations stage is characterized by the ability to think logically about abstract concepts and to develop, investigate and check hypotheses. It may also be the case that we develop those more abstract, formal thinking abilities only in our area of specialty. We may have some formal concepts in a given subject, say language, but not others. Even so, you might be able to handle oral language at the formal level but written language only at more concrete levels. An adult might be thinking hypothetically in the area of science, but not in his or her interpersonal relations. Another person might reach



abstract thinking in terms of morality but not mathematics. Reflecting on our knowledge of people around us, this may not be surprising. If you were a formal operational thinker in relation to the concept of negative numbers in mathematics, you would use the concept readily. When writing out a series of cheques, therefore, it is often simpler to go into negative numbers for the account balance and add the amount of transferred money later. (This assumes one has money to transfer.) How many people use this method? How many people will squeeze in a deposit amount (which may need changing later) purely to avoid negative numbers? In fact, some adults do not achieve formal operational thinking; most who do achieve it, do so in their area of strength only.

This affects what happens in secondary classrooms. The junior or senior high teacher is likely to be teaching in an area of specialty. That is most likely the area in which that teacher is a formal operational thinker. Most students, in junior high school certainly, are quite likely to be still thinking in concrete operational terms. This means that teachers and students think differently until the students learn to think in a formal operational manner.

Concrete Operational Thinking (about age 7 on)

If they think differently from their teachers, how do students think? In contrast with the preoperational stage where children focus on one easily seen aspect, in the concrete operational stage children are able to coordinate two aspects of a problem at the same time. When children become able to do this, they begin to play cooperatively, because they can take into account their friend's point of view as well as their own. This type of thinking can be called a linking reasoning: students link one thing to another. Junior high teachers are intuitively well aware of this. In giving a complex series of instructions, these teachers will break the instructions down into steps and give them out on a handout or write the steps on the blackboard. Lists can be handled easily with linking reasoning. The list keeps track of the large number of things to do. You have only two things to keep in mind: what you're doing now and where in the list you are.

A second characteristic of students' thinking at this stage is their ability to mentally reverse actions or operations. If a student can coordinate two points of view, then he or she can mentally go in either direction from one point to the other. This ability to reverse operations means the student can build a classification and break it back down into subgroups again. (Cats and dogs are both carnivores; carnivores as a general class can be subdivided into cats and dogs again.) In this stage, students can use a variety of mental operations such as ordering, or seriating, and a number of logical rules, such as compensation (to maintain the same weight, if I eat more, I must exercise more).

Junior high students are notoriously "present-oriented". (They can project into the future as far as the next party, or into the past as far as the last heartbreak.) Until the abilities to project and to hypothesize develop with formal operational reasoning, the students have little access to the past and future. At this stage, students depend on personal experience, and personalized content to link things. How can they have personal experience of the far past or the distant future? Hence, when dealing with topics such as career planning, concrete operational thinkers will tend to be somewhat unrealistic. They will base decisions on what they or their parents want rather than on what their capabilities are. It will not seem odd to them that although they've had 9 years of difficulty with math, they want still to be an engineer. Guest speakers are very effective with career or health topics because the students are willing to trust that person's experience. Where they haven't had the experience, they will trust the person who has had it. They are less willing to credit the teacher (or parent) telling them about another person's experience. Then the testimonial is too far abstracted from the original source. When a guest speaker "hooks" their attention, the teacher still has a large role in following up on the interest, and helping the students to translate interest into action.

The process of analysis provides a similar difficulty with abstraction from everyday experience. Students rely on personal or tangible experience. The more you analyze a process, the farther up the ladder of abstraction you travel. Concrete operational thinkers have difficulty going up that ladder. This means that reflective analysis of any process is difficult. Analysis must be done with heavy use of context and closeness in time to the students' experience of the process. Take, for example, language. To be engaged in a conversation is to experience language. To analyze language experience is to study grammar. Hence, grammar study is language about language. It is a meta-level operation, an abstraction. This makes analyzing language very difficult for concrete operational thinkers. They will tend to get through grammar study by memorization (and subsequent rapid forgetting). One can however, in context, use appropriate grammatical terminology to help understand a writing process. ("Your story needs more adjectives so I can visualize or see the events more clearly in my mind.")

Similarly, simulation games help students acquire skills. Often though, students will enjoy the game, but will not relate the game to the real process. They can acquire the skills, but not recognize where their use is appropriate. The students enjoy the class, but when asked at home what they have done in school that day, they reply "just played games." The message here is that the link must be made clear to the students and must be made directly to the parents.

Formal Operational Thinking

Age levels for this stage have not been forgotten. The difficulty is that some people (a very few) begin to think in this way at about age 11. Those students who develop formal operations usually do so at about age 15 (around grade 10). However, this

level of thinking, as explained earlier, may not be used in all areas of a person's life. Hence in any classroom, even at the grade 12 level, a large proportion of the students will still be thinking in concrete operational ways.

The development of formal operational thinking is the development of hypothetical thinking. The student or adult can now move up the ladder of abstraction. They can now organize all possibilities or combinations to a problem, rather than only one level of combinations. Students become able to handle more than simply two sources of information.

In mathematics for instance, the ability to organize all possibilities allows one to handle factoring polynomials. To recognize how $(2x + 3y)(x-y)$ forms the product $2x^2 + xy - 3y^2$ requires multiplying out all the possibilities:

$2x$ times x gives $= 2x^2$

$2x$ times $-y$ gives $-2xy$ (added) $= +1xy$

$3y$ times x gives $+3xy$

$3y$ times $-y$ gives $-3y^2$

Also, this ability to see all combinations, as well as to extract the relevant variable, underlies probability theory (or statistics) in mathematics. Often a student with good understanding of spatial concepts has done well in math up to grade 9, and then comes across these topics in grade 10. The student may suddenly have more difficulty with grade 10 math. This is not due to poor teaching or poor student study habits. Rather, the underlying abilities required have shifted from being more spatially based to those based more in formal logic. The student may have better skill in a spatial area than the logic, and therefore do better in one area than the other.

Hypothetical thinking is often described as "if-then" thinking. This linguistic structure (the conditional) acts as a signal for the possible use of the cognitive structure (hypothesizing). Children learn to use the linguistic structure, though, long before they use the cognitive one. A nine-year-old may say, "If I clean my room, can I go to the pyjama party?" In this case, the language is being used for immediate consequences. Similarly, the junior high class bargaining with the teacher for extra time is merely linking an immediate choice with a quick reward: "If we study quietly, may we have the test tomorrow instead?" They are not expressing the general case, that certain conditions of servitude gain particular rewards. True hypothetical thinking may state the specific case, but recognizes it as the application of a more general one. It is not merely a linking of two things or events.

A hallmark of the advance into the formal operational stage is the ability to handle multiple sources of information. Three way matrices become accessible. Therefore the student becomes able to handle the dihybrid cross in biology.

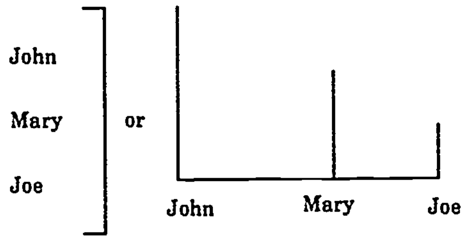
The student now becomes able to understand multiple levels of abstraction, and so can handle reflective analysis of a process. They begin to see, for example, how analyzing a story or poem can deepen one's appreciation of the work. They see that knowledge of syntax (grammar) can assist in turning an effective phrase. They recognize the connection of the simulation game to the actual process. The students become able to think about how they think. Many of the skills we assume in our secondary curricula and teaching really are automatically accessible only to students who are already formal operational thinkers.

THE LEARNING PROCESS

If we had a complete theory and practice developed for how students learn, we could also have a complete description of the instructional process. We are not yet at that stage, unfortunately. There are at least three things we do know about how students learn, where we have both research and theoretical support. These also help us pragmatically to improve classroom instruction. What are these three things? They are that:

1. how you set up a problem affects how easy it is to solve,
2. students can be taught to use higher order thinking skills automatically and
3. achieving formal operations requires students to have a wide base of experiences.

Psychologists have determined that clever people spend more time at the initial stage of a problem – organizing it and setting it up – than they do in the second stage – solving the problem. Less clever people plunge straight into the solution stage without taking the time to set it up well first. They then spend more time trying to solve it than the clever people spend at both stages. So, how a problem is organized can greatly affect how easily it is solved. For instance, a typical problem in transitive logic is the following: John is taller than Mary, Mary is taller than Joe. What is the relationship between John and Joe? Presented rapidly and orally, this is a difficult problem. Decoded to a visual format, it becomes easy:



How explicit are our guides and texts in teaching students to organize and re-organize information for themselves? Many teachers make use of various forms of concept maps for teaching students to organize information: do our texts include and support this practice?

The two ways of looking at the height problem above are two representations of the problem. They are both based on arrangements in space. The verbal description of the problem is a verbal representation. How we organize and present information affects the learning process. It is best for students to have a variety of representations so that they learn to use a variety of modes. Depending on the information, some representations are better than others. Advertisers are masters of setting up effective representations for their products – they try to combine several modes such as visual, oral, verbal, song and print. That is one reason television is so effective as an advertising medium. Each mode of representation reinforces the others but also adds something unique. Would a Coke commercial be the same without the jingle? In our curricula and teaching practice, how much variety do we provide in our representations of knowledge? A great contribution of the learning styles movement has been to alert us to the variety of teaching strategies and representations that we can incorporate into our curricula and our teaching.

Teaching for the Development of Formal Operations

If not all adults uniformly develop formal operations, then how do we help students to learn to think abstractly?

Students can be taught to use higher order thinking skills such as hypothetical thinking. In fact, they must be taught either in school or out of school. We know this because we know that not everyone achieves this level, even as adults. It does not happen purely as a result of development. It can be argued that students achieve the stage of formal operational reasoning because it is required of them and mediated to them.

How do teachers mediate? They do this through the types of contextual support they provide for tasks (and the tasks they choose). Teachers also do this through their talk – how they explain the tasks to students and how they talk about student responses. For example, a student folding flaps against a ruler for an art project was asked by a sensitive teacher, "How can you do two flaps at once?" The child was thereby encouraged to restructure the problem – not just to do the folding required, but to do it efficiently. This caused the child to examine the routine task in a new way – reorganizing its spatial aspects.

Another example of how teachers mediate children's time is the attention given (indirectly) to teaching analogic thinking. (Analogic thinking is thinking in analogies, such as cat is to dog, as kitten is to ______.) Even in elementary grades, teachers often use metaphor or simile poems with children. They plan these very carefully. Usually the teacher first gives an example poem:

> I am like a cat.
> I play.
> I sleep a lot.
> I purr when I am happy.

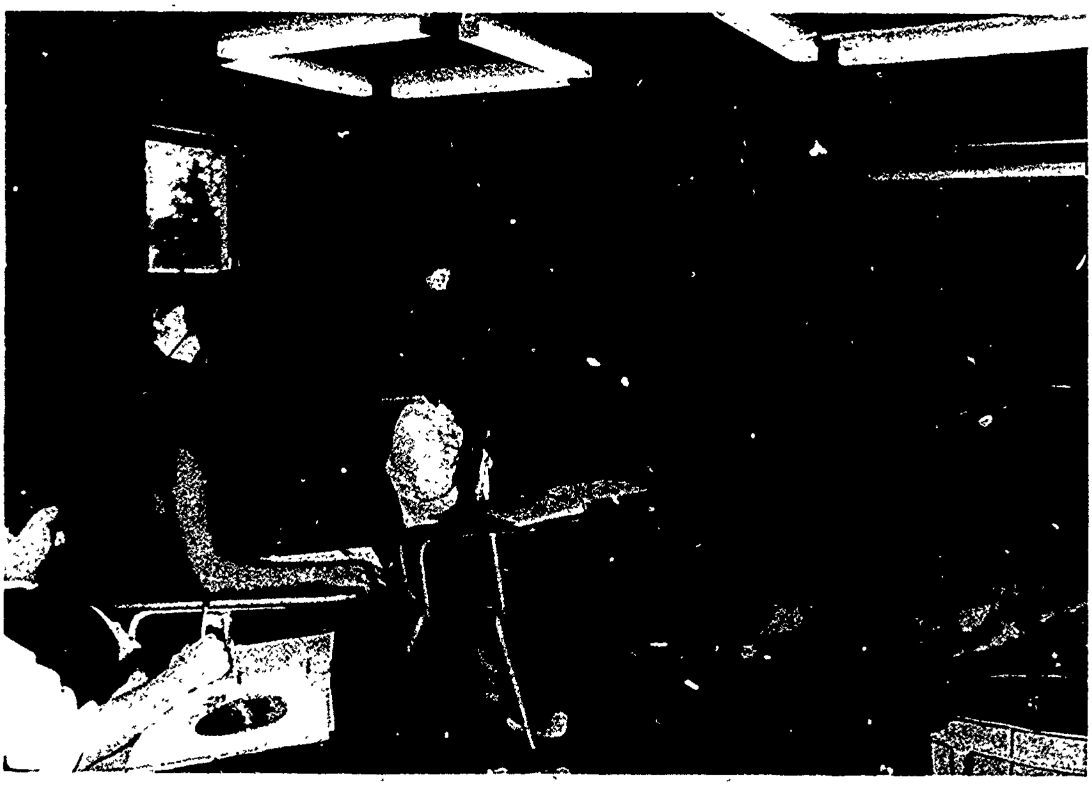
Then the structural elements of the poem are given to the children to build their own poems:

> I am like a _______.
> I _______.
> I _______.
> I _______ when I am _______.

Often the teacher may suggest familiar animals for the children to choose among, and he or she will certainly help them with characteristics of the animals which might be like themselves. This is mediation of the metaphor. As students go through the grades, teachers will often describe new concepts by saying they are like something familiar to the student. (The King acted like a father to his people.) By senior high school English classes, the effective use of metaphor can be analyzed in a formal operational manner. Without the work done building the concept of metaphor through context and mediation, however, throughout the grades, the formal study would not be possible at senior high.

Another important element to consider in developing thinking skills is practice. Students use skills with which they feel comfortable. To feel comfortable using a skill, you must practice it a lot. Do our curricula provide time for students to practice thinking skills until they become automatic? If every lesson presents new concepts and skills, how will students become comfortable with them? Would you want every driver on the road at rush hour to be a beginning driver? Surely we should ensure that curricula are not so overloaded with content that practice is overlooked. Furthermore, we would want all our curricula to integrate thinking skills so that the thinking skills are practised in all subject areas.

Students need a wide base of experiences to develop to their fullest potential. This is a truism we spout often. Consider what was said before, though: adults generally develop formal operational ability only in their area of specialty. That is the area in which they have broad experience. That is the area in which they are most comfortable, most practiced. Hence, it would seem that we must prepare students broadly but with sufficient depth and practice. In practical terms, how will we accomplish this? One way to provide practice without being merely repetitive is to vary our representations sometimes rather than always varying the content. To go back to our Mary, Joe, John height problem, three representations were given from purely verbal to almost purely spatial. For our content subjects, too, one could envision spatial concept maps as chapter summaries. Teachers can have students do these for themselves even where publishers have not yet added concept maps to the textbooks.



CONCLUSION

This paper has considered one main aspect of cognitive skills, the development of abstract thinking skills in the stage called Formal Operations. Of course, there is more to the full development of all the intellectual skills of an individual. The growth of language skills both supports and extends the growth of cognitive skills. Some of the methods suggested, such as the use of multiple representations, will encourage divergent thinking - one of the creative thinking skills. More can be done though, to develop students' creativity. An individual is complex, and it would take more than one short work to present a complete set of suggestions for the full development of each student.

This paper gives only some of the many ways teachers and others have found to enhance students' learning. As curriculum developers must understand the normal range of students' development to plan curricula, so too, teachers must understand the mix of abilities and aptitudes within their classrooms to plan instruction. It is hoped that this statement of students' growth will aid these various types of planning.

This paper consists of only one of the parts of the Developmental Framework. The school's task has as its primary focus the cognitive domain. However, without attention to the student's social/emotional and physical development, the school cannot accomplish its primary task. In truth, students grow and change in an integrated fashion. Growth in one domain supports and promotes growth in the other domains. For purposes of explanation, the domains are artificially separated, but in the students all domains must be considered and dealt with simultaneously.

USE OF THE FRAMEWORK

The framework and the accompanying guidelines are to be used by those who develop curricula. The framework provides a generalized (though still somewhat technical) developmental overview of stages typical of students in the junior and senior high schools. Those developing curricula can determine the difficulty levels of concepts and this would help to specify both when a concept should be taught and how much support it must be given, particularly in learning resource materials. Similarly, when available, the stages of affective growth may suggest appropriate course content at particular levels. Physical growth characteristics may also have implications for and about content activities. Thus, this framework has implications for **choice** of content, and for **sequencing** content, as well as for choosing appropriate learning **resources**.

For the teacher, this framework also has implications for curriculum implementation. It is important for teachers to know what mix of developmental stages each of their classes encompasses. It will help them to choose appropriate and varied support materials, to pitch their explanations to students' levels and to understand what students may find easy or difficult. This will help teachers to allot instructional time constructively, so that time on task is time appropriately spent on task.

In summary, then, knowledge of students' expected development and of particular students' stages of development can help to make instruction more effective. We must not only set tasks for students, we must set suitable tasks, give them adequate and varied support and have them use time appropriately. Time on task is only the beginning: **it must be quality time on the right task with good help.**

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APPENDIX "A"
COGNITIVE GROWTH

In their **COGNITIVE GROWTH**, students from about grade 2 use mainly:	Examples of contextual support are given for typical developmental stages. These are examples only and are not an exhaustive list.
Concrete Operational Thinking	**Examples of required Contextual Aid**
1. Reasoning	
Linking reasoning: Is done in terms of relating one thing to another (a linking type of relation). That thing may be an object, class, relation or number.	Limited number of elements at one time, e.g., experiments which consider only one variable at a time; in history, linking one event or result to one cause, then to a second and so on, one at a time. Have students learn to take notes so that fewer things are held in the mind at one time.
Operations used: Students can reason using mental acts such as classifying, or ordering (seriating). They know natural numbers, measurement of lines and surfaces and can use perspectives (or projective relations). Generally types of cause and effect, such as movement transmitted through a middle object, are understood.	Explanations of events and concepts employing these mental operations, e.g., historical events ordered along a continuum - closer or farther away from now. Biology can be taught through a classifying approach. Perspective can be taught in art. Networks or storywebs for understanding story structure.
Logical rules: Students understand how to reverse an operation through negating it (A >not A) and through reversing it (A-B, so B-A). They know the principles of identity and of compensation.	Examples, explanations, questioning to focus on relevant logical rule, e.g., "How do I know that this is the same as that?"
2. Time Frame Students are oriented to the present.	Past or future imbued with familiar human intentions and actions, e.g., story presentation
3. Awareness Students understand systems through using them and through engaging in processes, rather than by reflecting on or analyzing them.	Language taught through using language rather than analyzing it. 'Sciencing' or experimenting to draw conclusions. Simulation games only where clearly related to processes students already understand.
4. Representation Students have already learned to internalize actions in various ways such as symbolic play and mental imagery.	Simple, concrete representations of abstract concepts, e.g., base ten blocks, models, examples. These allow the student to for images to understand ideas.

In middle adolescence, many students continue to use concrete operational thinking, particularly in areas which are new or difficult for them. Therefore, work should begin at the level of concrete operations and go on to require some formal operational thinking.

Examples of contextual support are given for typical developmental stages. These are examples only and are not an exhaustive list.

Formal Operational Thinking	**Examples of required Contextual Aid**
1. Reasoning Students develop their ability to reason in terms of verbally stated hypotheses and propositional logic.	Opportunities to explore use of this faculty, e.g., directed discussions. Geometric proofs, debating.
Operations used: Students learn to use combinational analysis and permutation systems.	Explanations and questioning demonstrating these mental operations, e.g., probability and its outcomes in everyday statistics, psychology, citizenship skills.
Logical rules: Students become able to coordinate multiple sources of information or logical rules.	Opportunities requiring multiple coordination, explanations and representations for doing this (flow charts, tables, matrices).
2. Time Frame When students become able to hypothesize and deduce from their hypotheses, they are more able to go into the past or the future.	Past and future events presented through hypothesis. Extrapolation of trends. Moving a play scene from one time and place to another (e.g., Romeo and Juliet/WestSide Story).
3. Awareness Students begin to develop the ability to examine, analyze and reflect upon systems.	Parallel presentations of use of a system or process and analysis of it: the use of a grammatical system to understand language use. A 4-week rehearsal schedule in drama. Art or literary criticism.
4. Representation Students become able to represent or see things in terms of possibilities or hypotheses.	Means to represent spatially (Venn diagrams) and verbally. Note taking techniques such as outlining and concept mapping or networking. Drama - blocking a scene. Arts - planning compositional aspects.

APPENDIX "B"
AFFECTIVE AND PHYSICAL GROWTH
Early Adolescence

In terms of **AFFECTIVE GROWTH**, early adolescence is a turbulent time.

1. **Self-identity**

   Students become self-analytical and self-critical. They begin to seek to establish their mature self-identity. One common way of doing this is through comparison with their peers.

   Students continue to require a supportive, patient and positive learning environment. Role playing as an opportunity to experience a variety of models of interaction. Self-evaluation components in discussion with teachers.

2. **Emotionality**

   Extremes of emotions. They may first respond emotionally to experience.

   Exploration through discussion of emotionality appropriate to adolescence. Literature dealing with these issues may be helpful as vicarious experience. Drama activities.

3. **Social Interaction**

   Students have strong needs for affiliation (belonging) and for esteem.

   Group work and peer interactions will provide practice in this area for students. Specific rather than general praise.

4. **Moral Development**

   Students exhibit a variety of different stages of moral reasoning at these age levels.

   Peer interactions and opportunities for discussions about underlying issues can facilitate growth. Genuine student input into decision-making on issues which concern them will provide real practice (e.g., School/Class code of conduct).

In terms of **PHYSICAL GROWTH**:

1. **Growth Spurt**

   In early adolescence, students experience rapid and uneven physical growth. This can affect their sense of balance.

   Fitness and sport activities need to be monitored for safety during this period of development. Activities requiring good balance (gymnastics) may be difficult for those undergoing their growth spurt.

2. **Puberty**

   The development of secondary sexual characteristics can greatly affect students' social/emotional development. The normal age range for puberty spans age 10 or 11 to about 18.

   Context for discussion of physical changes at puberty. Consideration given to the relative advantages of same sex versus mixed groupings.

3. **Strength & Endurance**

   Student's strength levels vary greatly in adolescence due to individual differences and varied timing of puberty.

   The context should provide for activities which can accept varying strength levels and still provide some measure of success. Care in the selection of activities will allow for those which do not overtire.

4. **Skeletal Growth**

   Growth areas on long bones are immature and stress fractures can be caused by relatively stronger muscles pulling on weaker cartilage attached to bones.

   Excessive practice of one type of sport or movement should be avoided. Variety in activities is encouraged. Break long practice sessions into blocks interspersed with another type of activity.

Middle Adolescence

In terms of **AFFECTIVE GROWTH**, middle adolescents gain more equilibrium.

1. Self-identity

Students seek to establish personal, ethnic and career identities. Their sense of self is more realistic, incorporating positive elements and those needing improvement. Students develop independence and autonomy.

The environment context should still be secure, nurturing, sympathetic and non-judgemental to allow growth, consolidation and stabilization of the individual's sense of self. Students should be addressed as people who can succeed, and whose achievements are recognized.

2. Emotionality

Students begin to gain more equilibrium and balance in their emotions, and more control over them. Students attempt to exercise more independence.

Students' growing control and their expanding reflective awareness allow examination of their emotionality. Students should feel their contributions are valued and their humor has a place. Their affective responses to subject matter are natural by-products of the process.

3. Social Interaction

While peer relations remain strong, students develop particular friendships and become more sensitive to the needs of others. Interactions with the other sex become significant.

Exploration, discussion, and examination of social interactions and especially of relations between course work and personal experience. This may be a place for the contribution of a CALM course. Senior students plan an orientation for in-coming students.

4. Moral Development

Students continue to exhibit a variety of moral stages reaching to formulation of their own moral principles to guide behavior, perhaps including recognition of the idea of a social contract.

A variety of strategies is crucial because of students' varying stages of development. Peer interaction through discussion may facilitate growth. Group work.

In terms of **PHYSICAL GROWTH:**

1. Refinement of athletic abilities.

Opportunities for students to choose among sports and fitness activities, and to continue to refine skills in sports in which they are already proficient.

2. Development of strength, endurance and coordination.

Encouragement for students to experience sufficient types of sports to balance development in all aspects. Activities should allow successful participation by students of varying levels of strength, endurance and coordination.

3. Skeletal Growth may be incomplete.

Care in choice of exercise to avoid those which may damage growth areas on long bones. Adequate training for more strenuous activities, plus variation in movements when exercising. Stretching, relaxation exercises.